# Nuclear Fuel Cycle Options Catalog: FY16 Improvements and Additions

**Fuel Cycle Research & Development** 

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#### **SUMMARY**

The United States Department of Energy, Office of Nuclear Energy, Fuel Cycle Technology Program sponsors nuclear fuel cycle research and development. As part of its Fuel Cycle Options campaign, the DOE has established the Nuclear Fuel Cycle Options Catalog. The catalog is intended for use by the Fuel Cycle Technologies Program in planning its research and development activities and disseminating information regarding nuclear energy to interested parties. The purpose of this report is to document the improvements and additions that have been made to the Nuclear Fuel Cycle Options Catalog in the 2016 fiscal year.

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#### **ACRONYMS**

DOE U. S. Department of Energy FCDP Fuel Cycle Data Package

FY Fiscal Year

NEUP Nuclear Energy University Program

NLIT National Laboratory Information Technology

R&D Research and DevelopmentSNL Sandia National Laboratories

#### 1

# NUCLEAR FUEL CYCLE OPTIONS CATALOG: FY16 IMPROVEMENTS AND ADDITIONS

#### 1. INTRODUCTION

The United States Department of Energy (DOE), Office of Nuclear Energy, Fuel Cycle Technology Program sponsors nuclear fuel cycle research and development. As part of its Fuel Cycle Options campaign, the DOE is developing systematic, transparent, and objective processes to screen and evaluate a wide variety of proposed nuclear fuel cycles. The Nuclear Fuel Cycle Options Catalog is intended for use by the Fuel Cycle Technologies Program in planning its research and development (R&D) activities. The catalog is designed to

- Communicate fuel cycle information, including results from evaluations of proposed fuel cycles
  and their enabling technologies, that is part of the basis for Fuel Cycle Technology R&D investment
  decisions.
- Serve as a controlled source of input to fuel cycle evaluations and to screening analyses, such as those that are used to focus R&D investment in targeted areas.
- Archive information on nuclear fuel cycles and technologies, including information contributed by academic and industry stakeholders.
- Indicate whether nuclear fuel cycle options proposed in the future have been considered previously.
- Accumulate key results from fuel cycle analyses and related studies to support Fuel Cycle Technology R&D program planning by national technical directors and federal managers

The Nuclear Fuel Cycle Options Catalog is web-based and available to the public; it has been on the public site since March 2014. It can be found at

https://connect.sandia.gov/sites/NuclearFuelCycleOptionCatalog/SitePages/a/homepage.aspx

It can also be found on the Sandia National Laboratories (SNL) Nuclear Energy website. The home page of the Nuclear Fuel Cycle Options Catalog is shown in Figure 1 below.

The purpose of this report is to document the improvements and additions that have been made to the catalog during the 2016 fiscal year (FY).



Figure 1. Home Page of the Public Nuclear Fuel Cycle Options Catalog

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#### 2. IMPROVEMENTS AND ADDITIONS

Several fuel cycle options, reactors, and fuels were added to the catalog in FY16. In addition, a new online process for entering data from data packages was implemented, and a presentation was made to the National Laboratory Information Technology summit. These are discussed below.

#### 2.1 On-Line Fuel Cycle Data Package Entry Process

The current process for putting information regarding fuel cycle options, reactors, and fuels requires the person or group developing the information to complete a Fuel Cycle Data Package (FCDP). The FCDP can be either a System Datasheet or a Technology Datafile (Kim et al. 2013). A System Datasheet contains the information on the specific fuel cycle option, such as summary description of fuel cycle option, material flow diagram, mass flow data, references, etc. A Technology Datafile contains wiki-style generic information on a nuclear fuel cycle technology used in the fuel cycle option. The fuel cycle technologies include fuel type, nuclear power plant/transmutation system, and reprocessing/separations technologies.

In the current process, the FCDP is completed by the originators, and then is sent to an internal reviewer and an external reviewer. Once comments from the reviewers have been addressed, it is sent for final approval. Once the FCDP has been approved, the information in the FCDP is typed into the Fuel Cycle Options Catalog manually. To ensure that no mistakes were made in transcribing the information from the FCDP to the catalog, the information in the catalog is then verified by a knowledgeable person who is independent of both the development of the information and the inputting of the data into the catalog. Any data transcription mistakes are corrected, and the information is then made available on the public catalog website.

To streamline this process, SNL has added a process that enables fuel cycle option and technology developers to enter the data directly into the catalog with minimal assistance from SNL, have it reviewed as required, and have it approved before making it available on the public catalog website. The process is set up so that fuel cycle option and technology developers can enter parameter values and text directly into the catalog. However, additional information, such as diagrams and documents, will still need to be entered into the catalog by SNL personnel. The envisioned process calls for internal and external review after text, parameter values, diagrams, and documents have been entered into the catalog. Once the reviewers have approved the information, it would be made available on the public catalog website without needing to be verified by another independent reviewer. The verification process would be part of the initial review process, not an additional step.

This capability, called the Option Manager, has been developed during FY16 and is currently being tested by inputting six fuel cycle options received via the Nuclear Energy University Program (Section 2.3). A sample webpage for entering the parameters for a pressurized water reactor for a sample option is shown in Figure 2. The remaining tasks to be completed include developing a review and approval procedure and developing instructions for users.

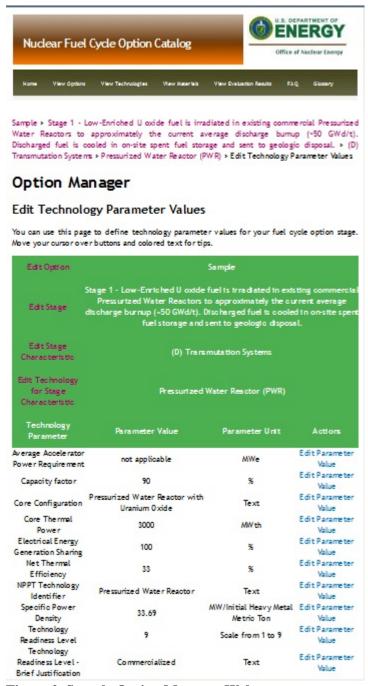


Figure 2. Sample Option Manager Webpage

#### 2.2 Information Added to the Catalog

Over the course of FY16, several new options, two reactors, and a fuel were added to the catalog and their verification was completed. The six options that were added are:

• Externally driven sub-critical reactor using metallic fuel, continuous recycle

- Intermediate sodium-cooled reactor using carbide fuel, continuous recycle
- Self-sustaining reduced-moderation boiling water with an intermediate spectrum recycling plutonium and uranium-233, continuous recycle
- Molten salt reactor with continuous recycle of uranium and plutonium with natural uranium feed fuel
- Reduced-moderation boiling water intermediate reactor recycling transuranics and uranium-233, continuous recycle
- Sodium-cooled fast reactor using plutonium and uranium; molten salt thermal reactor using plutonium and uranium fuel, continuous recycle

The interactive flow diagrams for these six fuel cycle options are shown in Figure 3 through Figure 8. When these diagrams are viewed on the website, clicking on an item in the diagram, such as a fuel, opens another window with information about that item.

The two reactors that were added are:

- Supercritical water reactor
- High-conversion water reactor

Diagrams for these reactors are shown in Figure 9 and Figure 10.

The fuel that was added is:

• Reduced-moderation boiling water intermediate spectrum fuel, shown in Figure 11.

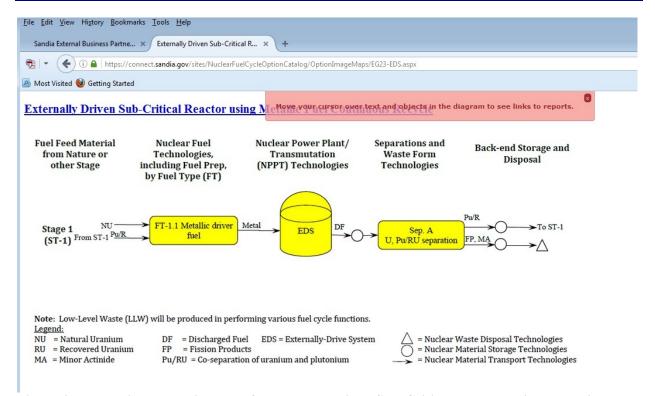


Figure 3. Interactive Flow Diagram of Externally Driven Sub-Critical Reactor using Metallic Fuel, Continuous Recycle

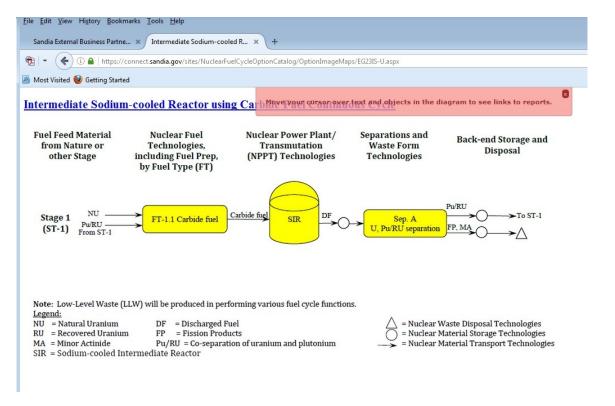


Figure 4. Interactive Flow Diagram of Intermediate Sodium-Cooled Reactor using Carbide Fuel, Continuous Recycle

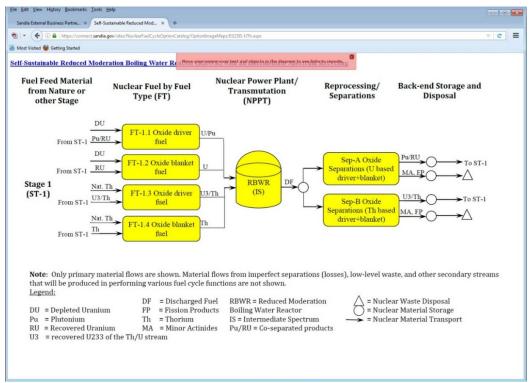


Figure 5. Interactive Flow Diagram of Self-Sustaining Reduced-Moderation Boiling Water Reactor with an Intermediate Spectrum Recycling Plutonium and Uranium-233, Continuous Recycle

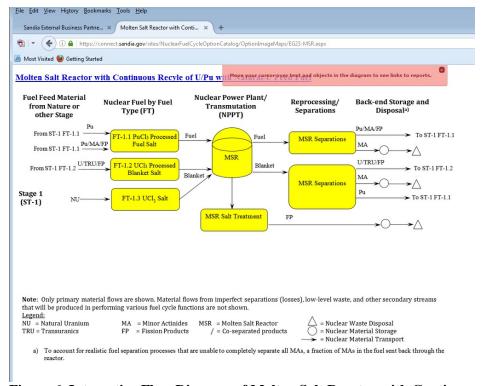


Figure 6. Interactive Flow Diagram of Molten Salt Reactor with Continuous Recycle of Uranium and Plutonium with Natural Uranium Feed Fuel

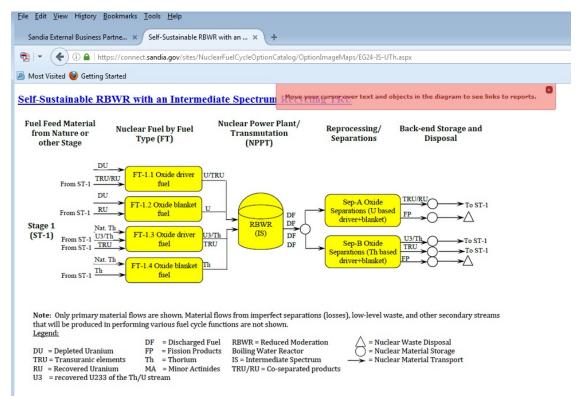


Figure 7. Interactive Flow Diagram of Reduced-Moderation Boiling Water Intermediate Reactor Recycling Transuranics and Uranium-233, Continuous Recycle

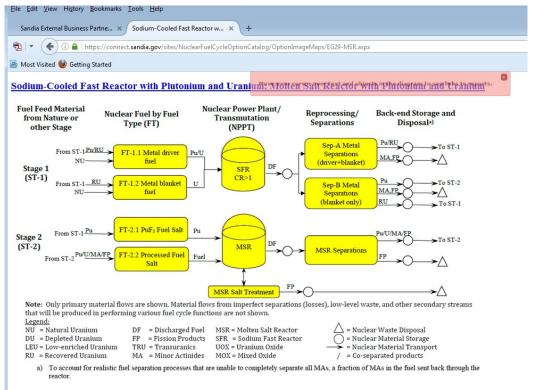


Figure 8. Interactive Flow Diagram of Sodium-Cooled Fast Reactor using Plutonium and Uranium; Molten Salt Thermal Reactor using Plutonium and Uranium Fuel, Continuous Recycle

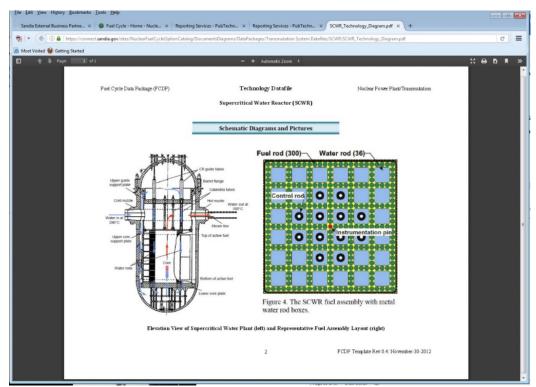


Figure 9. Diagram of Supercritical Water Reactor

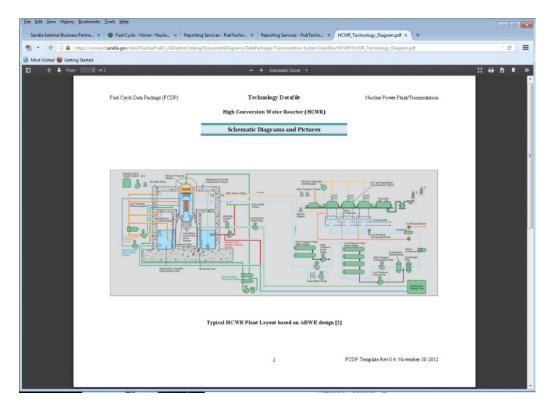


Figure 10. Diagram of High Conversion Water Reactor

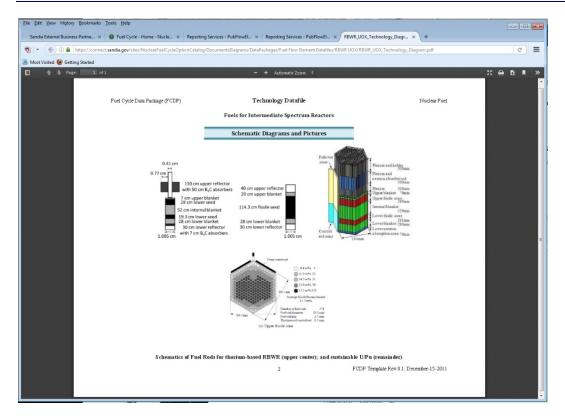


Figure 11. Diagram of RBWR Intermediate Spectrum Fuel

# 2.3 Presentation to the National Laboratory Information Technology Summit

In May, the National Laboratory Information Technology (NLIT) Society sponsored the NLIT Summit to facilitate the exchange of best practices and ideas between information technology professionals within the DOE complex, strengthen the information technology infrastructure, and reduce costs within the DOE laboratory system. The Summit was held in Albuquerque. Catalog personnel prepared slides and made a presentation about the catalog's purposes, requirements, and architecture; the resources that were available to develop and maintain the catalog and why they were used; the data model used to develop the catalog database; how users managed data via web interfaces; and the database reports that allow users to search and navigate the site. The slides shown at the NLIT Summit are shown in Appendix A.

#### 2.4 Information in the Process of Being Added to the Catalog

Two universities associated with the NEUP, Purdue University and Vanderbilt University, each submitted three fuel cycle options via FCDPs. The data from these FCDPs is being entered into the catalog using the on-line FCDP entry process described in Section 2.1; this process will be completed in FY17. These six fuel cycle options and the universities that submitted them are:

- Pressurized water reactor using low-enriched uranium fuel; heavy water reactor using plutonium, recovered uranium, and thorium (Vanderbilt University)
- Heavy water reactor using low-enriched uranium; molten salt reactor using transuranics, thorium, and recovered Uranium -233 (Vanderbilt University)

- Pressurized water reactor using low-enriched uranium and thorium; high temperature gas cooled reactor using recovered thorium and uranium-233 (Vanderbilt University)
- Sodium-cooled fast reactor using transuranics and uranium in metallic fuel assemblies (Purdue University)
- Sodium-cooled fast reactor using plutonium and uranium in metallic fuel assemblies; accelerator-driven system using minor actinides and an inert matrix fuel (Purdue University)
- Sodium-cooled fast reactor using plutonium, uranium, and minor actinides in metallic fuel assemblies; accelerator-driven system using minor actinides and an inert matrix fuel (Purdue University)

#### 2.5 Ongoing Maintenance Activities

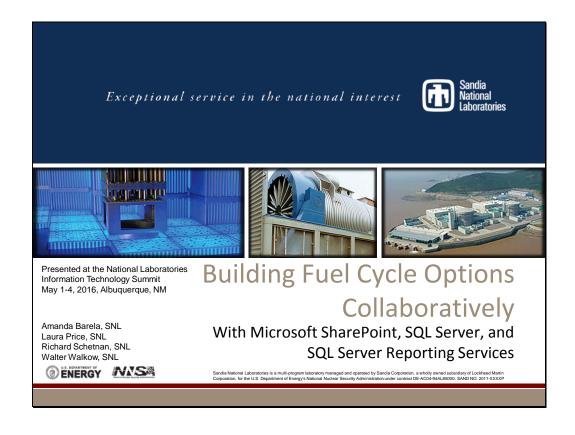
FY16, the catalog staff also performed ongoing maintenance activities, such as making sure the website and database continued to work when SNL's network managers updated software or equipment.

#### 3. REFERENCES

Kim, T. K., E. A. Hoffman, and T. A. Taiwo, 2013, *Completion of Fuel Cycle Data Package System Datasheets for 2013 Evaluation and Screening*. ANL-FCT-333, FCRD-FCO-2013-000165, Fuel Cycle Research and Development, U.S. Department of Energy, Office of Nuclear Energy, Washington, DC.

#### Appendix A

The slides shown at the NLIT Summit held in Albuquerque in May 2016 are shown below.



### What Is the Fuel Cycle Technology Program, and What Is the Fuel Cycle Option Catalog?



- The Nuclear Fuel Cycle Option Catalog is part of the Fuel Cycle Technology Program, a program of the U.S. Department of Energy's Office of Nuclear Energy that sponsors nuclear fuel research and development.
- The catalog is primarily intended for use by the Fuel Cycle Technology Program in planning its research and development activities. Other users may include power utilities, universities, and members of the public who are interested in nuclear energy research and development.



What Is the Fuel Cycle Technology Program, and What Is the Fuel Cycle Option Catalog? (continued)



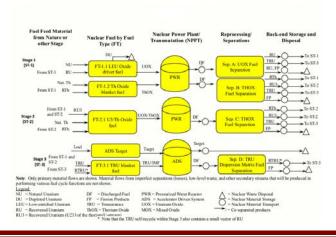


- Information contained in the catalog is primarily based on analyses to improve understanding of differences in performance among various fuel cycles (complete nuclear energy systems from mining to disposal).
- These analyses inform the decision-making process at the Department of Energy for planning and conducting long-term research and development.

#### What Does the Nuclear Fuel Cycle Catalog Contain?



- The Nuclear Fuel Cycle Catalog contains information about:
  - Technologies and materials that may be used to produce electricity from nuclear energy.
  - Performance of proposed nuclear fuel cycle options, including nuclear waste management considerations, proliferation and nuclear material security risks, safety and environmental impacts, and development and deployment risks.



## Where Does the Fuel Cycle Option Catalog Content Come From?



- Content comes from a collaboration among the U.S. Department of Energy and several national laboratories.
- In 2014, the U. S. Department of Energy provided 40 fuel cycle options screened from a larger group of options.
- Addition nuclear fuel cycle options have been provided by the Fuel Cycle Technology Program, which includes participation from:
  - Argonne National Laboratory (content and review)
  - Brookhaven National Laboratory (content)
  - Idaho National Laboratory (content and review)
  - Lawrence Livermore National Laboratory (content)
  - Oak Ridge National Laboratory (content and reviewer)
  - Pacific Northwest National Laboratory (content)
  - Savannah River National Laboratory (content verification)





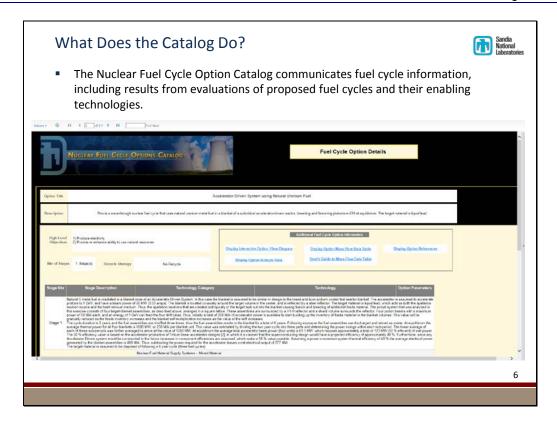


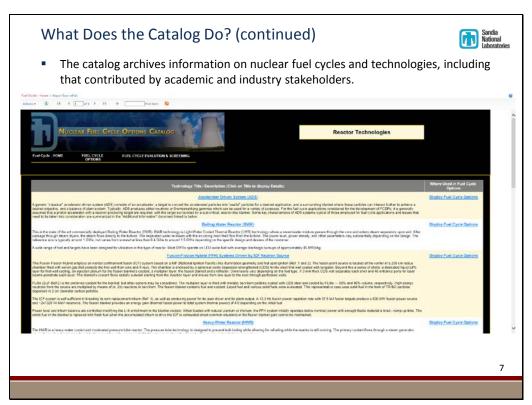


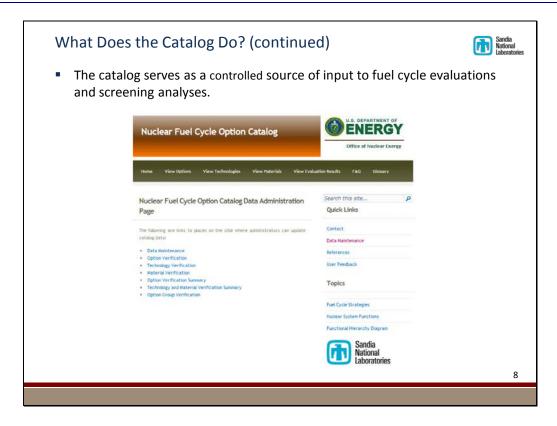


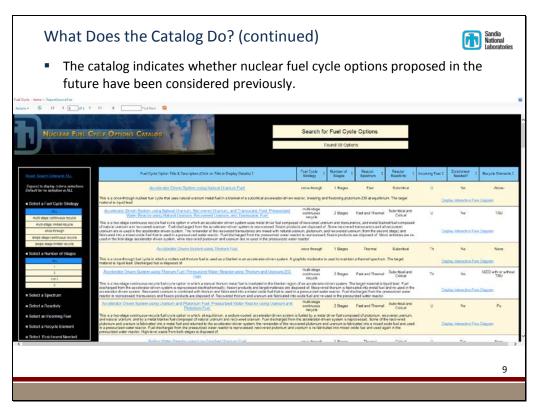


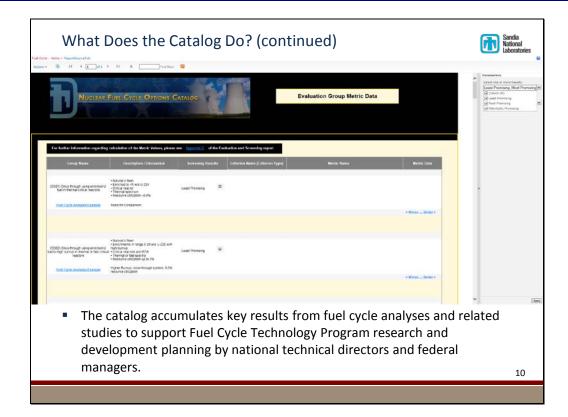


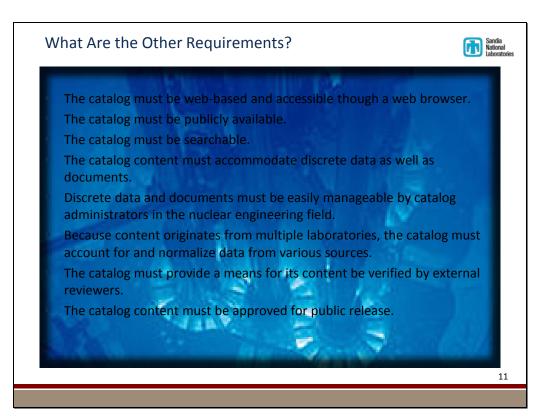












# What Personnel Resources Were Available for Developing and Maintaining the Catalog?



- One nuclear engineer to:
  - Provide subject matter expertise.
  - Provide an interface to the Nuclear Fuel Cycle Program and interpret the program's requirements.
  - Be the project manager.
  - Enter data.
- A graduate student intern (later a staff member) to enter data.
- A database administrator to:
  - Set up and maintain the database.
  - Design the data model.
  - Construct views and stored procedures.
  - Create and deploy the reports.
- A programmer to code up the web interface.

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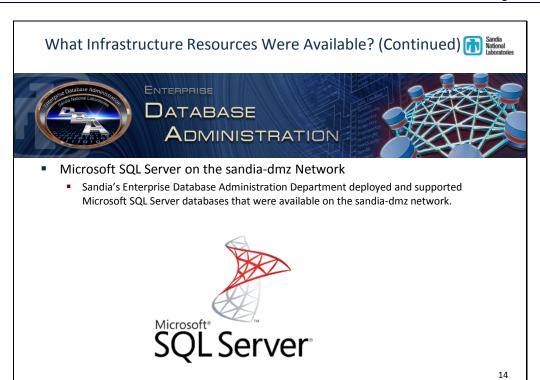
#### What Infrastructure Resources Were Available?



- SharePoint on Sandia's External Collaboration Network
  - Sandia's Infrastructure Computing Services deployed and maintained SharePoint on the External Collaboration Network at https://collaborate.sandia.gov.
  - Users outside of Sandia could access collaborate.sandia.gov by getting an account for the sandia-dmz network.
  - Infrastructure Computing Services later deployed another SharePoint server at <a href="https://connect.sandia.gov">https://connect.sandia.gov</a>.
  - Access to connect.sandia.gov does not require an account on the sandia-dmz network; users may create accounts on the fly to gain access to sites.







#### What Made SharePoint Attractive?





- Can serve as both a document repository and web application platform.
  - SharePoint services are available through an API that can be accessed through JavaScript and JQuery to create AJAX web applications.
  - SharePoint provides interfaces to external data sources through external content types and external lists. External content types can make use of database views and stored procedures.
- Eliminates the need to stand up and maintain a web server.
- Has outstanding corporate support and doesn't cost anything to use.



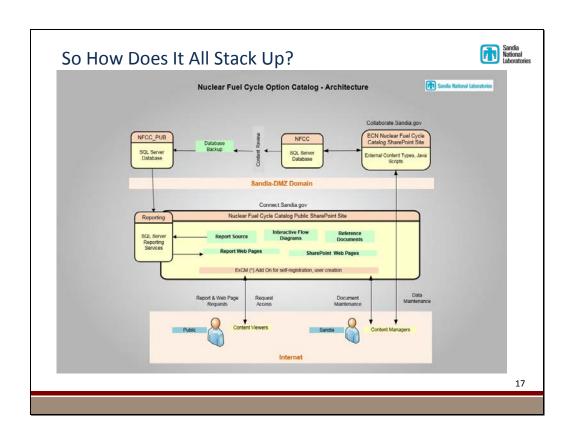
#### What Made SQL Server Attractive?

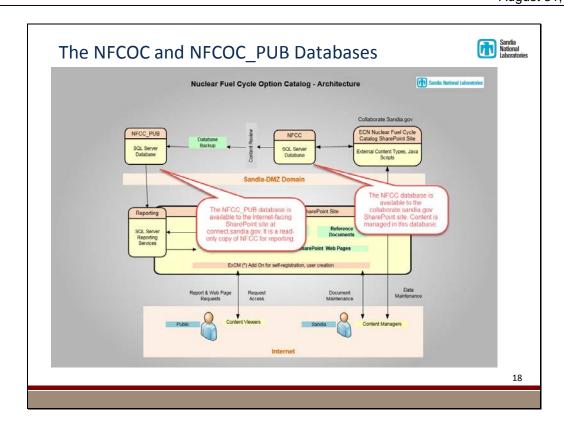


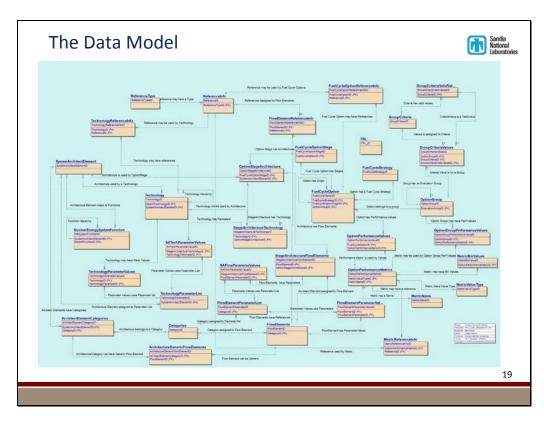




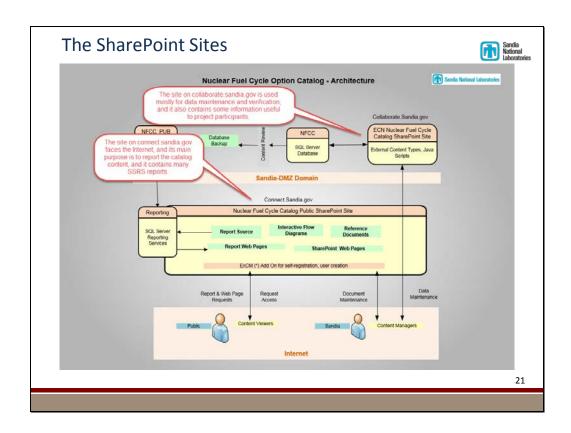
- Full-featured database management system.
- Enterprise Database
   Administration provides
   terrific support at a
   reasonable cost.
- Lots of available SQL Server tools and expertise.
- Works well with SharePoint external content types.
- Reports generated with SQL Server Reporting services integrate nicely with SharePoint.

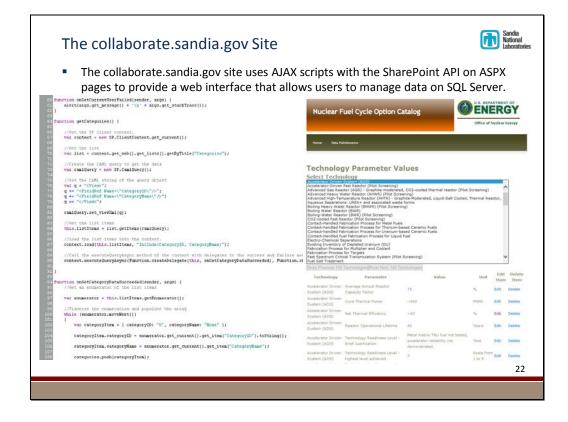






# create procedure doc.tCT\_Update\_TechnologyParameterValues # 45 tables # 116 views # 161 stored procedures # SET NOCOUT ON Begin Update\_doc.technologyParameterID # Servicedible doct.technologyParameterID # Servicedible doct.technologyParam







#### So What?



- Corporately supported SharePoint and SQL Server resources on Sandia's external networks have been valuable assets for deploying applications for collaboration among the U.S.
   Department of Energy, the national laboratories, and the public.
- Corporately supported resources are economical and even cost-free in some cases, and they are often underutilized.
- Taking advantage of those resources allows staff to focus limited human resources on the things that staff members are good at.

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#### Comments, Questions, Discussion



